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Update on the Science of Ozone Health Effects

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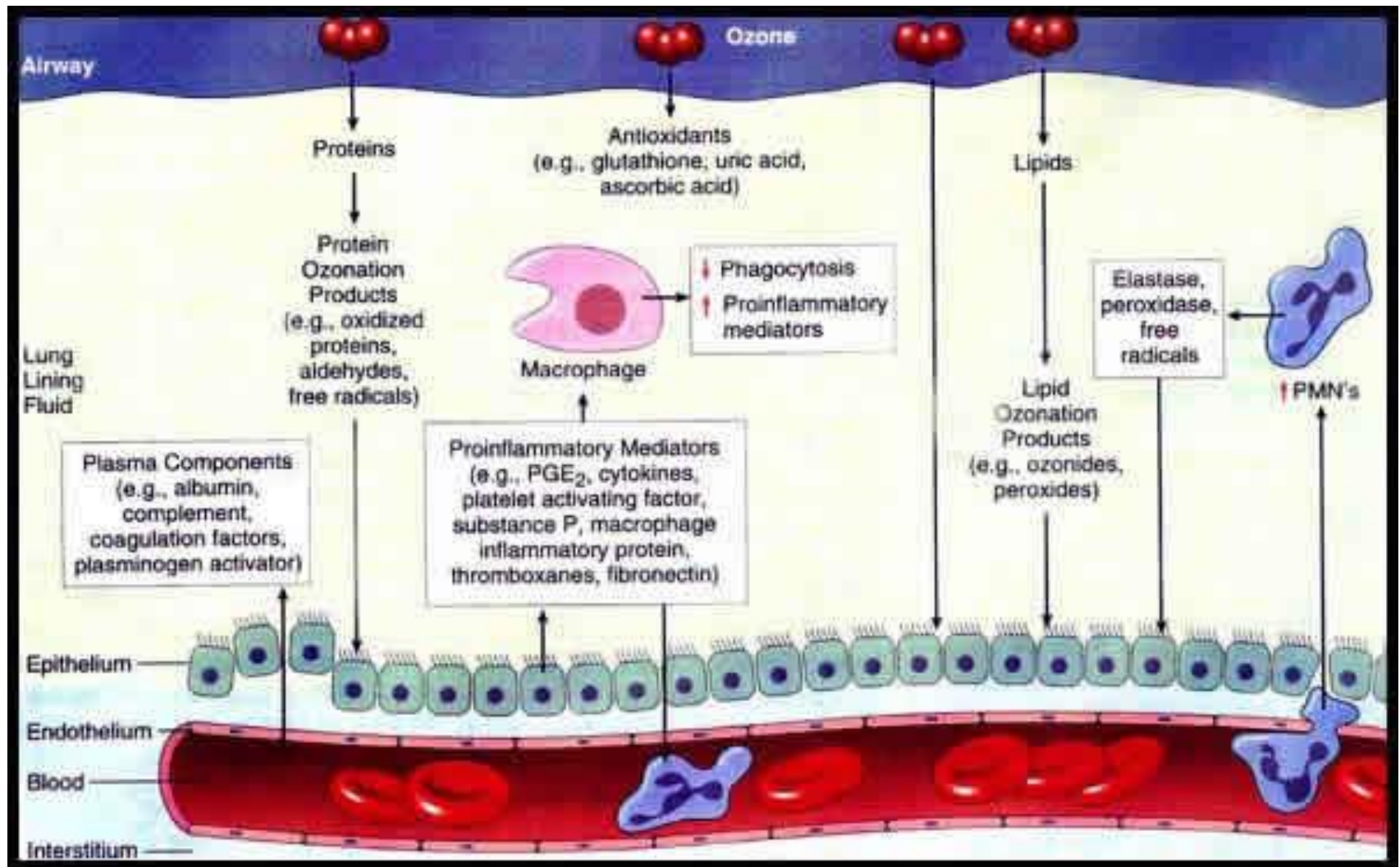
Objectives

- Identify known health effects of ozone
- Introduce key issues:
 - Establishing causation
 - Dose-response relationships
 - Sensitivity of individuals/groups
 - Health and economic costs

Ozone (O₃) Toxicity

- Reactive, strong oxidant
- But poorly soluble → gets deep in lungs
- Oxidation → injury (damage to cells)
- Inflammation → release of mediators into body
- Reversible health effects: symptoms, inflammation, loss of lung function, asthma attacks
- Irreversible health effects: loss of lung function, new-onset asthma, respiratory and cardiovascular mortality

Mechanisms of O₃ Toxicity



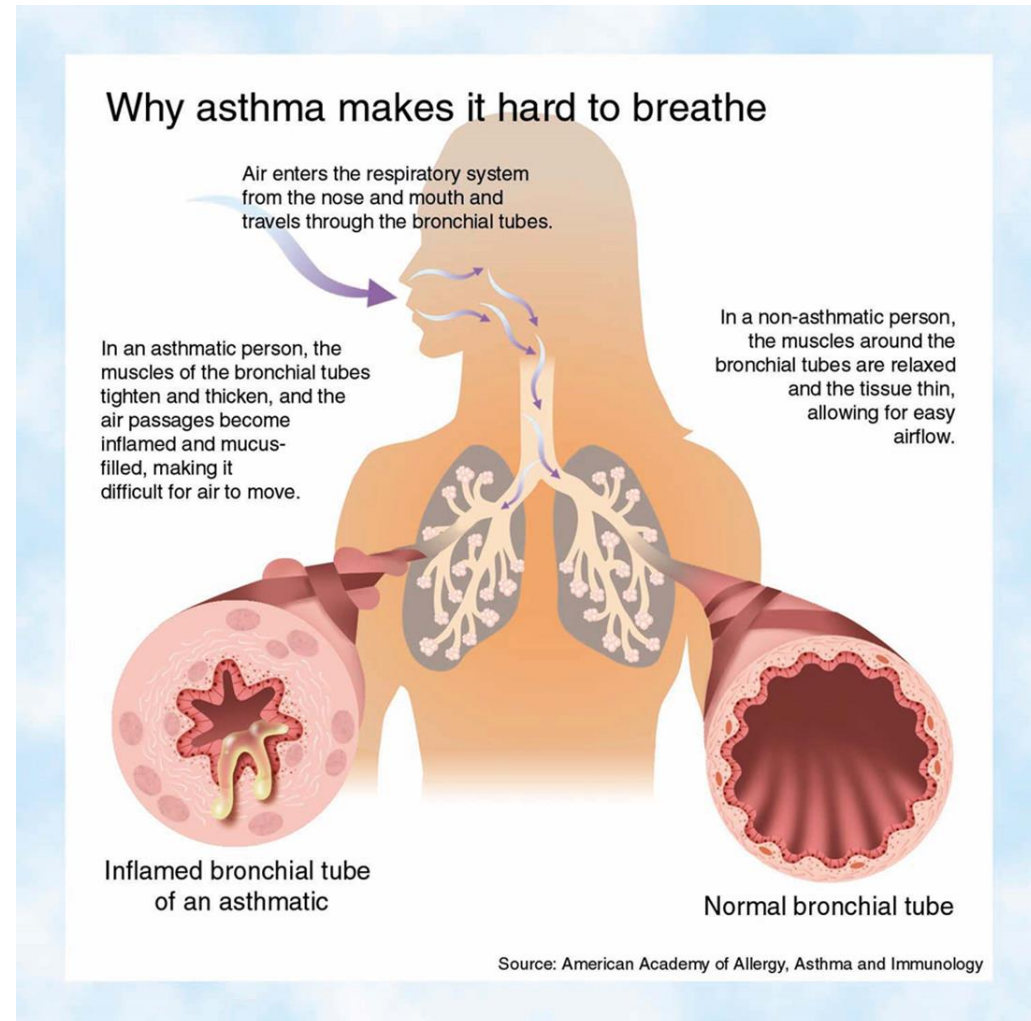
Does O₃ cause _____ (health effect)?

Factors considered:

- Is it biologically plausible?
- Is the observed epidemiological association strong?
- Is the association consistent across studies?
- Is there experimental evidence?
- Is there a exposure-response relationship?
- USEPA weight-of-evidence determinations:
 - “Causal relationship”
 - “Likely to be a causal relationship”
 - “Suggestive of a causal relationship”
 - “Inadequate to infer a causal relationship”
 - “Not likely to be a causal relationship”

Health Effects of Short-Term O₃

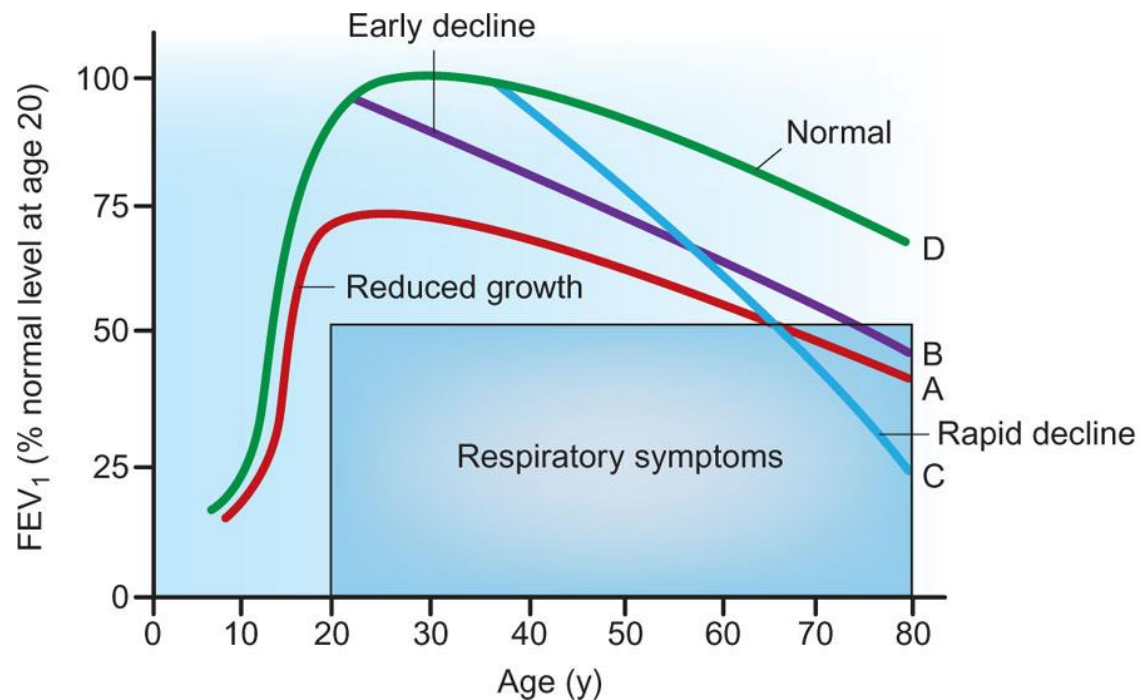
- Respiratory effects (*causal*)
 - Respiratory irritation, cough, reduced lung function
 - Airway hyperreactivity
 - Asthma attacks
 - Hospitalizations
- Cardiovascular effects (*likely to be causal*)
 - Heart attacks, sudden cardiac death, worsening of heart failure



Health Effects of Long-Term O₃

- Respiratory effects (*likely to be causal*)
 - Reduced lung growth
 - New-onset asthma

Model of changes in lung function over a lifetime in health and disease



(From Weiss, S. Nature Genetics 2010)

Questions Beyond Causation

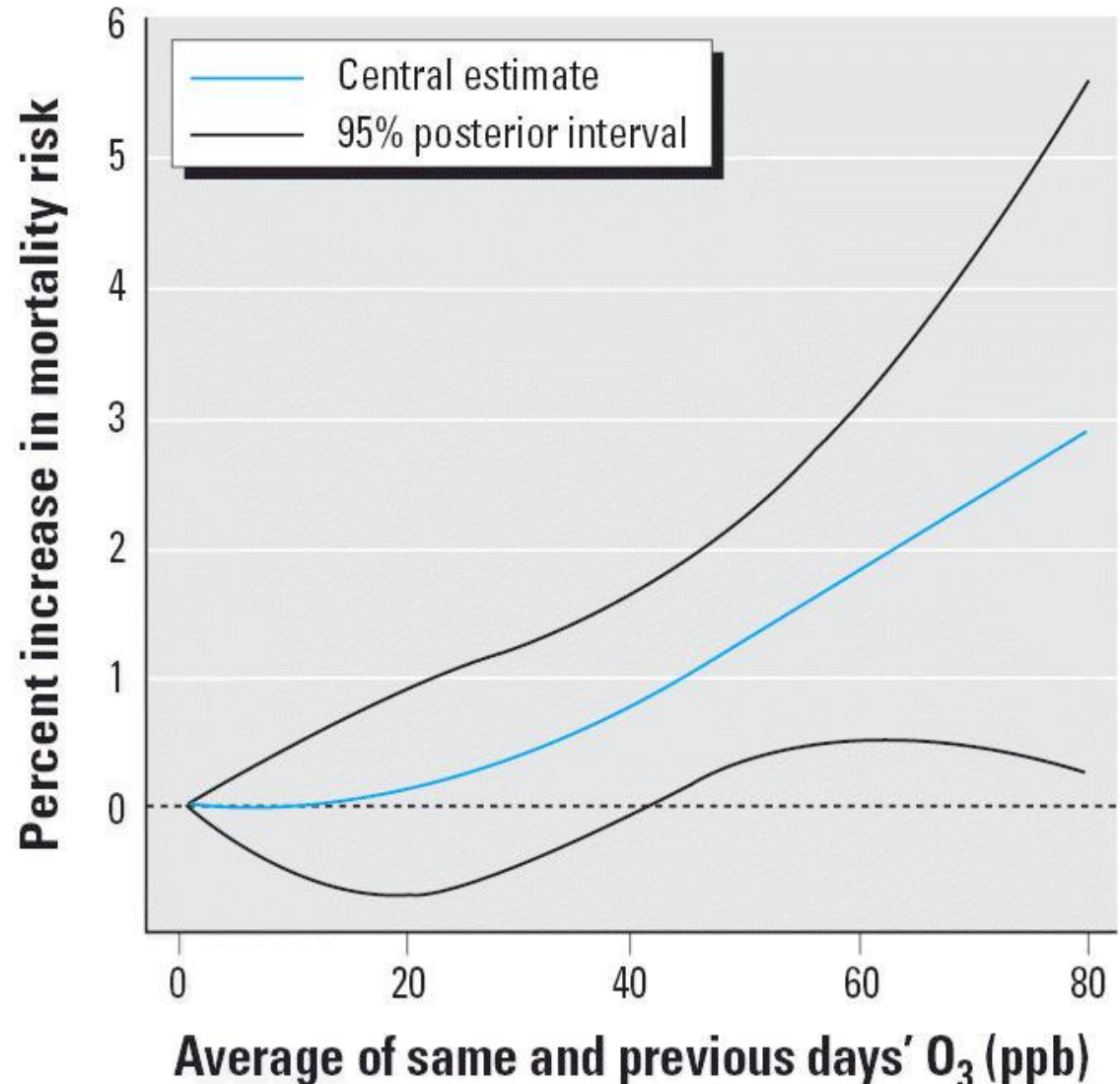
- Clean Air Act:
 - EPA to set standards to protect public health, including the health of sensitive populations including asthmatics, children, and the elderly.
 - Allowing an adequate margin of safety
- How low is low enough?
- EPA Integrated Science Assessment 2013
(<http://www.epa.gov/ncea/isa/ozone.htm>)

Sensitive Groups

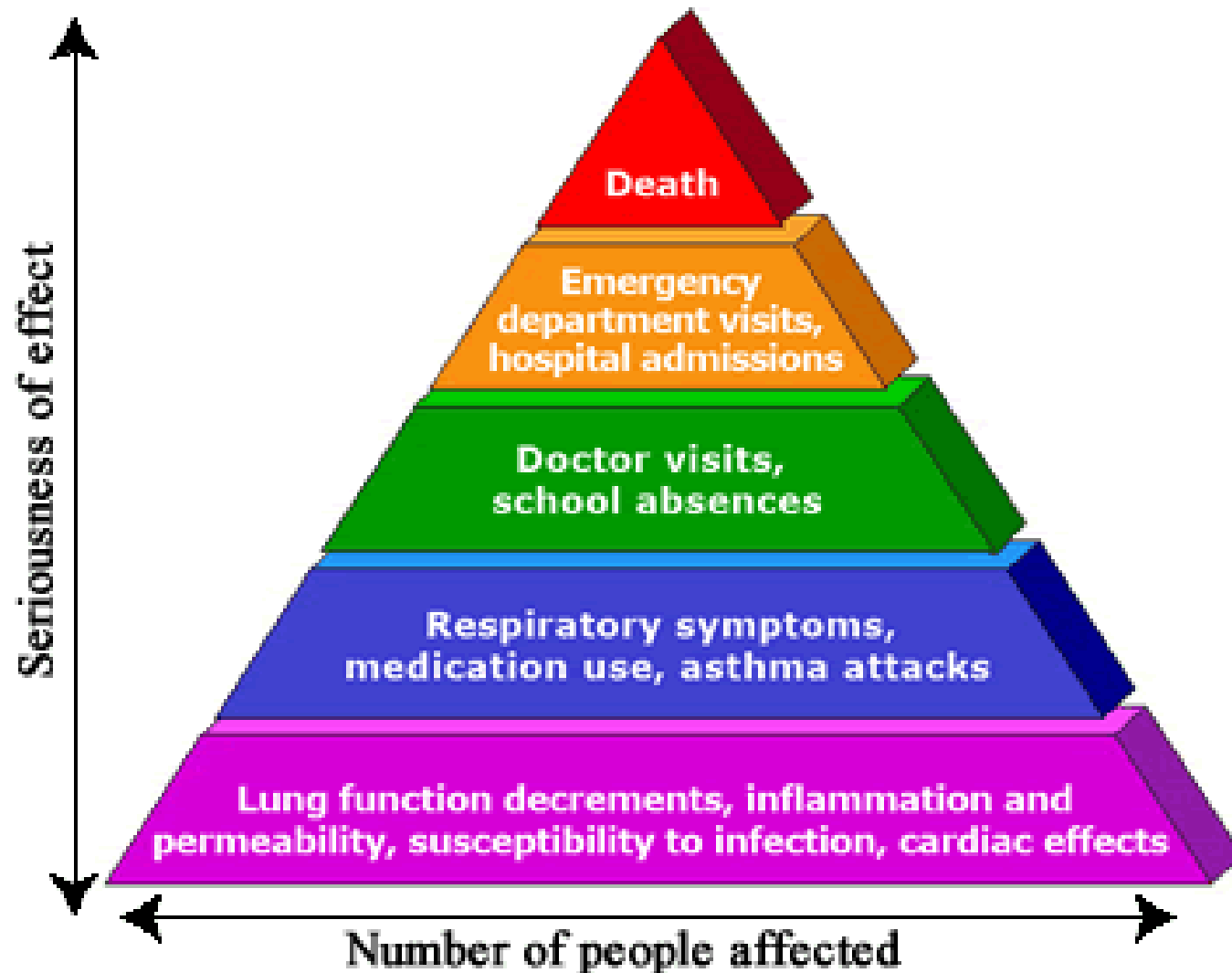
- People who have asthma:
 - Increased inflammation and sensitivity to allergens
- Children:
 - More vulnerable due to greater exposure, growing lungs
- Elderly:
 - More susceptible to pulmonary and cardiovascular effects

Ambient O₃ and Total Mortality

Time-series study
of daily mortality
experience of 98 US
cities from 1987 to
2000
(Bell et al EHP 2006)

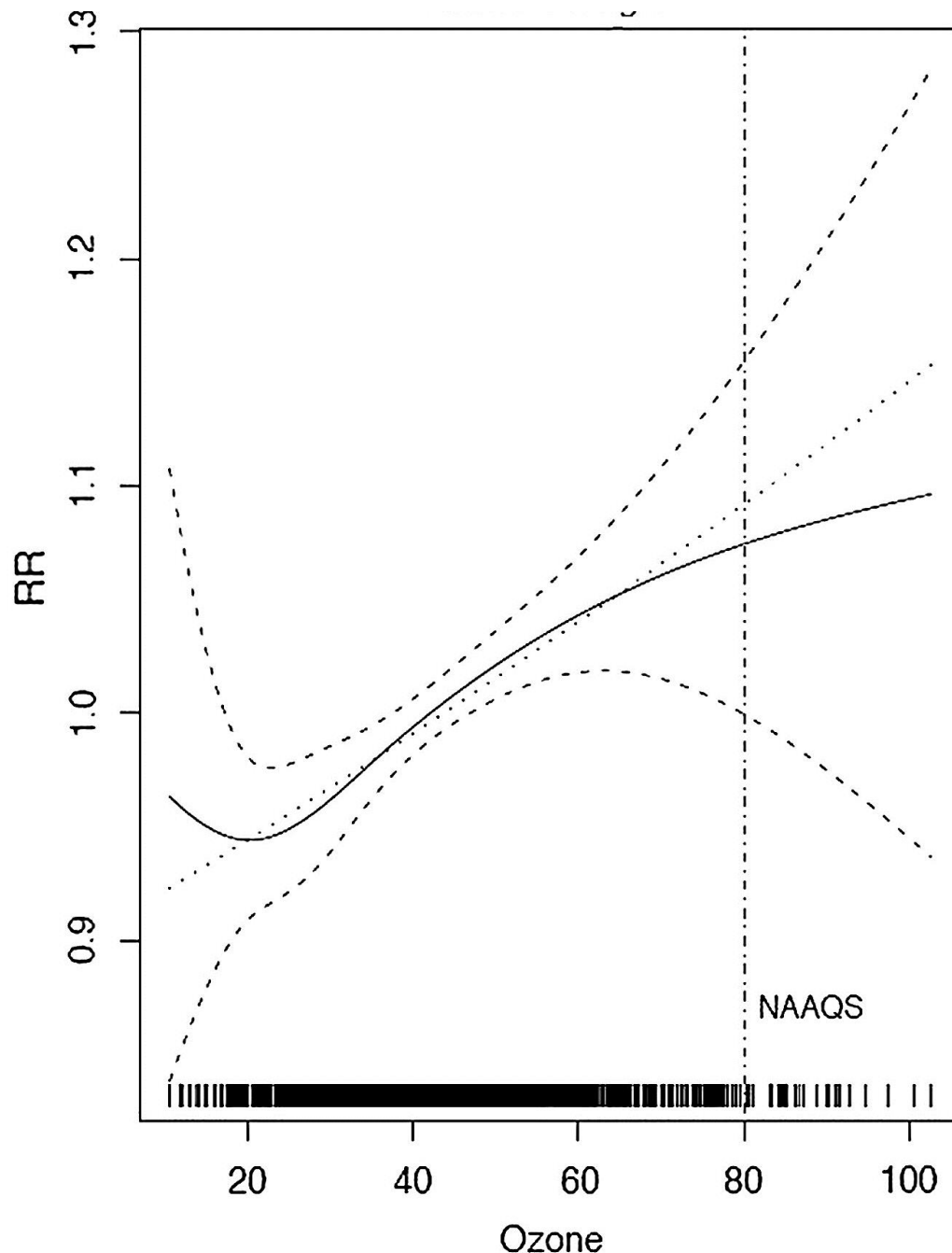


Pyramid of Effects (the Iceberg)



Ambient O₃ and Hospital Admissions for Asthma

Daily time-series of asthma admissions to 74 NYC hospitals 1999-2006. Estimated relative risks (RR) of asthma hospital admissions for 8-hr max O₃ concentrations at lag 0-1 days.

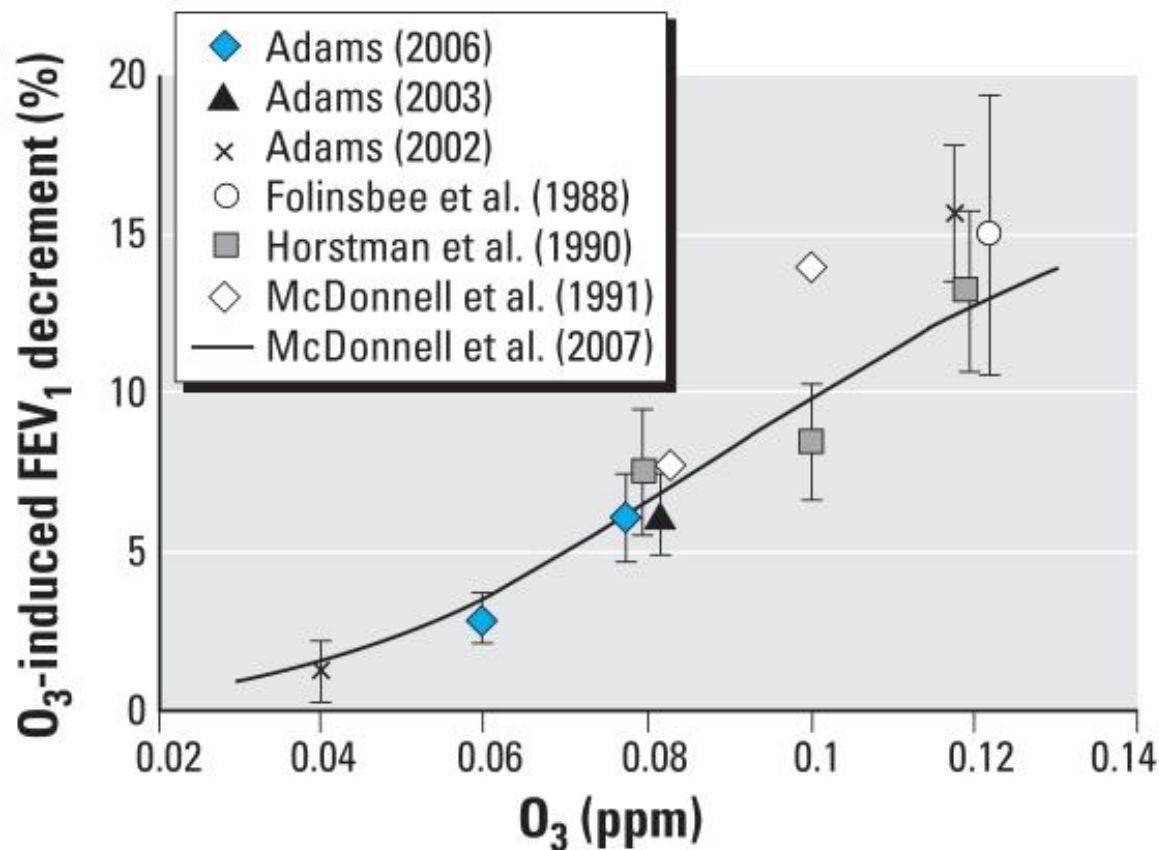


(Silverman JACI 2010)

Controlled Exposure Studies of Short-term O₃:

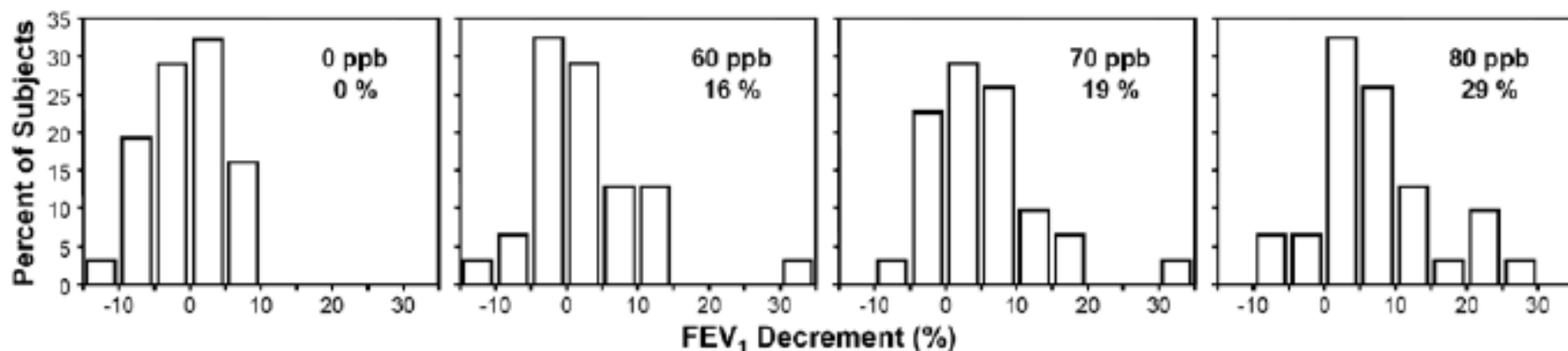
Is there a threshold for lung function response?

Cross-study
comparison of
average FEV₁
decrements due
to 6.6 hr exposure
to O₃ with
moderate exercise



(Brown et al EHP 2008)

Controlled exposure studies of short-term O₃: Individual variability in FEV₁ decrement



Distributions of % change in FEV₁ among 31 healthy male and female participants aged 18-25 exposed to 0, 60, 70, and 80 ppb O₃ for 6.6 hours with exercise

(Schelegle, AJRCCM 2009)

Direct and Indirect Costs of O₃ Pollution

- Economic:
 - Medical care: hospitalization, emergency care, routine care, medications
 - Absenteeism: missed work and school days
 - “Presenteeism”: reduced productivity
 - Premature death: years of productive life lost
- How do we put a value on health?

Benefits and Costs of Lowering the O₃ Standard (USEPA)

- An ozone standard in the proposed range of 65-70 parts per billion has public health benefits worth an estimated:
 - \$6.4 to \$13 billion for a standard of 70 ppb
 - or \$19 to \$38 billion for a standard of 65 ppb.
- These benefits outweigh the costs, estimated at:
 - \$3.9 billion for a standard of 70 ppb
 - or \$15 billion for a standard of 65 ppb.
- Reducing ozone and particle pollution nationwide (excluding California) in 2025 will avoid:
 - 710 to 4,300 premature deaths
 - 320,000 to 960,000 asthma attacks among children
 - 330,000 to 1 million days when kids miss school
 - 65,000 to 180,000 missed work days
 - 1,400 to 4,300 asthma-related emergency room visits
 - 790 to 2,300 cases of acute bronchitis among children

Conclusions

- Evidence supports health effects of O₃ below 70 ppb (8 hr)
- Ozone pollution at current levels has high human and economic costs

Questions?